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QUATERNARY BARNACLES FROM THE GALÁPAGOS ISLANDS

By

Victor A. Zullo

Department of Earth Sciences, University of North Carolina at Wilmington, North Carolina 28403

Abstract: Quaternary marine deposits on six islands in the Galápagos Archipelago have yielded at least nine species of balanomorph barnacles, seven of which are present in the extant Galápagan fauna. The mid-intertidal species *Tetraclita milleporosa* Pilsbry and the lower intertidal to subtidal species *Megabalanus galapaganus* (Pilsbry) and *Balanus trigonus* Darwin are most common. The whale barnacle *Coronula diadema* (Linnaeus) and the turtle barnacle *Chelonibia testudinaria* (Linnaeus) are represented by unique specimens at separate localities. *Balanus poecilus* Darwin and a shell tentatively identified with *B. calidus* Pilsbry were found at one locality. A species of *Concavus* that might represent *C.* (*Arossia*) *panamensis eyerdami* (Henry), and a *Tetraclita* shell bearing marked similarity to that of *T. rubescens rubescens* Darwin were present at single localities. Neither *Concavus* nor *Tetraclita rubescens* is known from the extant Galápagan fauna.

Introduction

As a participant in the 1964 Galápagos International Scientific Project, I had an opportunity to study the extant cirriped fauna of the Galápagos Archipelago, and to collect a few fossil barnacles from Cerro Colorado on Isla Santa Cruz. Some aspects of the extant fauna were published (Zullo 1966; Zullo and Beach 1973). The lack of adequate fossil material has prevented any serious speculation on the antiquity of the extant fauna and, indirectly, on the antiquity of intertidal and shallow-water habitats in the Galápagos Archipelago.

During February 1982, Carole Hickman, Matthew James, Jere Lipps, and Lois and William Pitt made an extensive survey of fossiliferous marine deposits in the Galápagos. Of the 84 samples taken on seven islands, 12 localities on six islands contained barnacle remains (Fig. 36, 37). Lipps and Hickman (1982) argued that none of the Galápagan fossil localities is older than two million years, and that some types of deposit are only a few hundred years old. This conclusion is contrary to previous Miocene or Pliocene age estimates for several of these localities (e.g., Dall and Ochsner 1928; Durham 1964), but the completely modern aspect of the fossil barnacle fauna would appear to support a Quaternary age assignment.

Paleontology

All of the species represented by fossils are either found today in the intertidal zone or at depths less than 20 m. The mid-intertidal species *Tetraclita milleporosa* Pilsbry, and the low intertidal zone and shelf species *Megabalanus galapaganus* (Pilsbry) and *Balanus trigonus* Darwin are the most abundant fossils. The remaining species, including *Balanus* sp., cf. *B. calidus* Pilsbry, *B. poecilus* Darwin, *Concavus* (*Arossia*) sp., cf. *C.* (*A.*) *panamensis eyerdami* (Henry), *Tetraclita* sp. indet., *Chelonibia testudinaria* (Linnaeus), and *Coronula diadema* (Linnaeus) are represented by one or a few specimens from single localities. Quaternary distribution of barnacles mirrors modern distribution patterns. *Tetraclita* *milleporosa* and, particularly, *Megabalanus galapaganus* prefer high energy environments and are most abundant and grow to greatest size on windward sides of islands in areas of considerable wave action. *Balanus trigonus,* on the other hand, prefers low energy environments on the leeward sides of islands or in protected areas below wave base. *Balanus calidus* and *B. poecilus* are most common in current-swept areas below wave base.

Table 1 indicates the relationship between fossil barnacle occurrences and orientation of localities with respect to prevailing wind direction. The majority of localities yielding specimens of *Tetraclita milleporosa* and *Megabalanus galapaganus* are on southeast-facing shores that presently bear the brunt of wave energies generated by the southeast trade winds. *Balanus trigonus,* on the other hand, is found predominantly at localities on west-facing, or present leeward shores. Only at CASG locality 61392 does *B. trigonus* occur with *Megabalanus galapaganus.* This apparent contradiction can be explained by the presence of *Balanus* sp., cf. *B. calidus* and *B. poecilus,* both subtidal species, and the small size of the *Megabalanus galapaganus* specimens, typical of subtidal populations. Locality 61392 probably represents a depositional environment below wave base with substantial current action. The two leeward *Tetraclita* localities are notable in that neither has yielded *B. trigonus,* suggesting that local wave energies were sufficient to maintain *Tetraclita* populations, but too high to permit establishment of *B. trigonus.*

Origin of the Galápagan Barnacle Fauna

The major objective sought in this study, but not completely attained, was a clue to the time of origin of the Galápagan barnacle fauna. Clearly, the modern Galápagan fauna was already established in the Pleistocene, and its origins must be looked for in Neogene deposits, if such deposits exist. This conclusion is supported by studies of north temperate and tropical eastern Pacific Cenozoic barnacle faunas. The major faunal break occurs at the Tertiary-Quaternary boundary, with the barnacles of the Pleistocene being essentially of modern aspect, whereas those of the Pliocene are primarily of extinct species-groups that evolved at the end of the Oligocene.

The presence of *Concavus* cannot be adequately explained. The two subspecies of *Concavus* (*Arossia*) *panamensis* (Rogers) range throughout much of the Panamic faunal province (Newman 1982). It is possible that the species has been overlooked in the extant fauna, or was eliminated from the fauna in the recent past.

Systematics

Superfamily Coronuloidea Newman and Ross
Family Coronulidae Leach
Subfamily Chelonibiinae Pilsbry
Genus **Chelonibia** Leach

Chelonibia testudinaria (Linnaeus, 1767)
Figures 3, 4

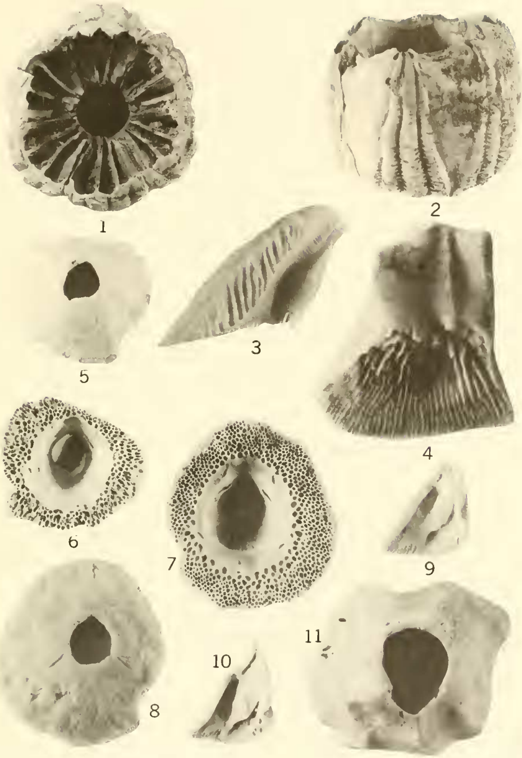
Material.—One lateral compartment, CASG locality 61281.

Discussion.—The single lateral plate in the collection is 31 mm high and has a basal width of 28 mm. The presence of deep cavities between basal septa and well-developed oblique grooves and ridges on the radial and alar edges of the paries readily identify this specimen with *C. testudinaria.* This common and widely distributed turtle barnacle has been reported from the Pacific loggerhead, green, hawksbill, and ridley turtles. Fossils are known from Miocene and younger

Table 1. Distribution of Environmentally Sensitive Galápagan Fossil Barnacles with Respect to Locality Orientation.

	Orientation of localities*										
	E-facing	SE-facing (windward)					W-facing (leeward)				
Species	392	387	281	282	285	286	386	388	389	390	391
Tetraclita milleporosa		X	X	X		X	X				X
Megabalanus galapaganus	X		X	X	?	X					
Balanus trigonus	X							X	X	X	
Balanus sp., cf. *B. calidus*	X										
Balanus poecilus	X										

* Locality numbers in table are last three digits of CASG numbers (e.g., *61*392).



FIGURES 1–11. Fig. 1, 2. *Coronula diadema* (Linnaeus, 1758), basal and side views of shell, hypotype CASG 61364, CASG locality 61229; ×1.3. Fig. 3, 4. *Chelonibia testudinaria* (Linnaeus, 1767), lateral and interior views of lateral plate, hypotype CASG 61365, CASG locality 61281; ×1.6. Fig. 5–11. *Tetraclita milleporosa* Pilsbry, 1916. Fig. 5, 6. Exterior and basal views of shell, hypotype CASG 61366, CASG locality 61387; ×1.6. Fig. 7, 8. Basal and exterior views of shell, hypotype CASG 61367, CASG locality 61386; ×1.6. Fig. 9. Interior of scutum, hypotype CASG 61368, CASG locality 61286; ×2.7. Fig. 10. Interior of scutum, hypotype CASG 61369, CASG locality 61286; ×2.7. Fig. 11. Exterior of shell rasped by fish, hypotype CASG 61370, CASG locality 61282; ×1.6.

deposits in Mediterranean, Atlantic, and Caribbean regions (Zullo 1982). To my knowledge, this is the first reported fossil occurrence of *Chelonibia* from the Pacific basin.

Subfamily Coronulinae Leach
Genus **Coronula** Lamarck

Coronula diadema (Linnaeus, 1767)

Figures 1, 2

Material.—One complete specimen, CASG locality 61229.

Discussion.—The single specimen is 27 mm in height and its greatest diameter is 31 mm. The well-developed transverse corrugations on the external surfaces of the transverse flanges suggest the ornamentation seen in the Pliocene species *C. barbara* Darwin, but the absence of similar corrugations on the inner surfaces of the flanges and the lack of infilling between radii and the alar plates indicate that the Galápagos *Coronula* is merely a highly corrugated specimen of *C. diadema.*

Coronula diadema, with a modern cosmopolitan distribution on humpback, fin, blue, and sperm whales (Newman and Ross 1976), has been reported from numerous Pliocene and Pleistocene localities in the Pacific basin region.

Family Tetraclitidae Gruvel
Subfamily Tetraclitinae Gruvel
Genus **Tetraclita** Schumacher

Tetraclita milleporosa Pilsbry, 1916

Figures 5–11

Tetraclita porosa var. *communis* Darwin, 1854:329 (in part).
Tetraclita squamosa milleporosa Pilsbry, 1916:257, pl. 60, fig. 1–1d; Newman and Ross 1976:48.

Material.—One shell, CASG locality 61386; one shell, CASG locality 61387; one shell, CASG locality 61391; one shell, CASG locality 61281; 21 shells, two partial shells, CASG locality 61282; 28 shells, four compartmental plates, six scuta, and one partial tergum, CASG locality 61286.

Discussion.—The extant tropical American taxa *T. milleporosa, T. panamensis* Pilsbry, *T. stalactifera stalactifera* (Lamarck), *T. stalactifera confinis* Pilsbry, and *T. stalactifera floridana* Pilsbry form a group within the genus *Tetraclita* characterized by similarities in shell coloration and opercular plate morphology that readily distinguish them from other *Tetraclita* species and suggest close phylogenetic relationships. It is assumed that *T. milleporosa,* known only from the Galápagos Archipelago, was derived from a mainland *T. stalactifera* stock. In the eastern Pacific, subspecies of *T. stalactifera* are restricted to Panamic faunal province mainland localities. *Tetraclita panamensis* occurs along the Central American Pacific coast, but is also found on Bay of Panama islands. The intertidal *Tetraclita* of Cocos Island off the coast of Costa Rica appears to be conspecific with *T. panamensis,* but may represent a distinct subspecies.

The opercular plates of *T. milleporosa* are similar to those of *T. stalactifera,* but the shell of the Galápagos species differs in being thicker and having much smaller and more numerous parietal tubes. *Tetraclita milleporosa* approaches *T. panamensis* in thickness and density of small pores, but differs particularly in opercular plate morphology.

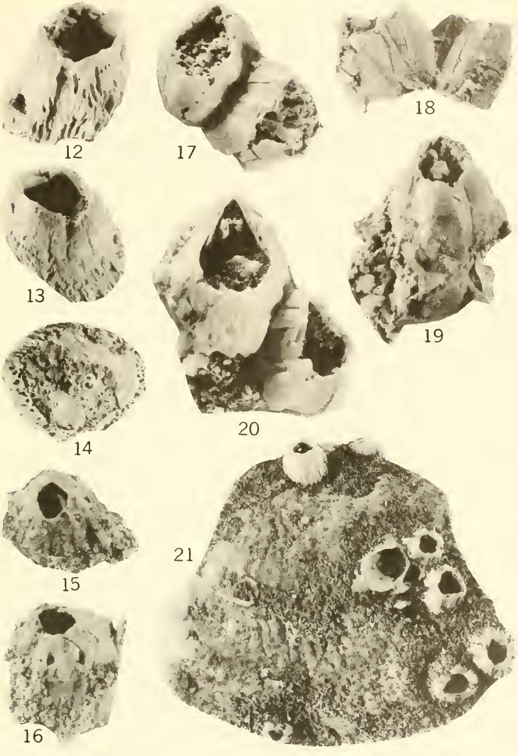
None of the fossils in the present collections shows any deviation from morphologies exhibited by extant *T. milleporosa* populations. The shells (Fig. 5–8) are typical of *T. milleporosa* in being peltate, and in having tiny orifices, obscure sutures, eroded external surfaces exposing infilled parietal tubes, and thickened walls with very small and numerous parietal tubes. A few shells show evidence of rasping by fish (Fig. 11). The well-preserved scuta from CASG locality 61286 (Fig. 9, 10) are typical as well, being about as high as wide, with small, closely set denticulae on the inflected occludent margin, and a relatively short adductor ridge that nearly merges with the lower part of the articular ridge, being separated by only a shallow groove. The tergum is too worn to be of aid in identification.

Tetraclita sp. indet.

Figures 12–14

Material.—One shell without opercular plates, CASG locality 61286.

Discussion.—A single shell associated with numerous specimens of *T. milleporosa,* from CASG locality 61286, represents a second species of *Tetraclita.* The shell is high conic, with a relatively thin shell wall and correspondingly fewer rows of parietal tubes formed of larger individual tubes. The radii are narrow, but well developed and conspicuous, and the exposed filling of the upper parts of the parietal tubes is red. This shell is remarkably similar to that of *T. rubescens rubescens* which presently ranges between San Francisco, California and Cabo San Lucas, Baja California. The combination of shell features,



FIGURES 12–21. Fig. 12–14. *Tetraclita* sp. indet., lateral and basal views of shell, hypotype CASG 61371, CASG locality 61286; ×2.5. Fig. 15, 16. *Balanus* sp., cf. *B. calidus* Pilsbry, 1916, top and lateral views of shell, hypotype CASG 61372, CASG locality 61392; ×2.5. Fig. 17–19. *Balanus poecilus* Darwin, 1854, CASG locality 61392; ×2.5. Fig. 17, 18. Top and side views of shells, hypotype lot CASG 61373. Fig. 19. Lateral view of shell, hypotype CASG 61374. Fig. 20, 21. *Balanus trigonus* Darwin, 1854, CASG locality 61388. Fig. 20. Top view of shells, hypotype lot CASG 61375; ×2.5. Fig. 21. Shells on *Anomia peruviana* Orbigny, hypotype lot CASG 61376; ×1.6.

particularly the color of the internal filling of the parietal tubes, is unlike that of *T. milleporosa* or any of the known Panamic faunal province species. The Panamic species, related to or conspecific with *T. stalactifera*, range in color from gray to purple-black, usually lack well-defined radii, and usually have a conic shell with a small orifice. If this unique specimen is indeed representative of *T. rubescens*, I am at a loss to explain its presence in the Pleistocene Galápagan fauna.

Superfamily Balanoidea (Darwin) Newman and Ross
Family Balanidae Darwin
Subfamily Balaninae Darwin
Genus **Balanus** Da Costa

Balanus trigonus Darwin, 1854
Figures 20, 21

Material.—Ten shells, CASG locality 61388; two shells, CASG locality 61389; one shell, CASG locality 61390; six shells, CASG locality 61392.

Discussion.—Although shells characteristic of *B. trigonus* were collected at the four localities listed above, no opercular plates were present in the collections. *Balanus trigonus* is found in most of the warm-water regions of the world from the lower intertidal zone to the edge of the shelf, but is most common in those parts of the immediate subtidal and inner-shelf zones that are protected from wave shock. In the Galápagos Archipelago, extant *B. trigonus* is abundant on the leeward sides of islands in the lower intertidal and immediate subtidal.

Considering the widespread distribution and abundance of this species in modern shallow seas, few verifiable reports of fossil *B. trigonus* exist. The species is fairly common in Pleistocene deposits of the Gulf of California region (Ross 1962) and has been identified by William A. Newman (personal communication 1982) from the Pleistocene of Hawaii. To my knowledge, fossil *B. trigonus* has not been reported from the western margins of the Pacific basin. Western Atlantic reports of *B. trigonus* include those of Withers (1953) from the (?)Miocene of Cuba, and of Ross (1965) from the Pliocene Tamiami Formation of Florida. Ross's (1964) report of this species from the Pliocene Yorktown Formation of Virginia was later stated to be in error (Ross 1965). Western Tethyan reports include those of Kolosváry (1957) from the Tortonian (Miocene) of Hungary, and Davadie (1963) from the Pliocene of Italy, the Red Sea, and the Coralline Crag of England.

These fossil occurrences, coupled with the modern distribution of the species, would suggest that *B. trigonus* is an old Tethyan element that has managed to survive to the present. There are two problems, however, that cause me to question this conclusion. First, many of the aforementioned reports are based on species lists without substantiating descriptions or illustrations. Their validity is placed in question particularly in the knowledge that other students of barnacles who have monographed the faunas of the same regions (e.g., Darwin 1854; Alessandri 1906; Menesini 1966) did not uncover *B. trigonus*. Secondly, although both extinct and extant representatives of the *B. trigonus* complex are common in Neogene and Pleistocene deposits of southern California and the southeastern United States that I have examined (e.g., Zullo 1979), *B. trigonus* is absent. This is particularly odd, because the faunas of these units indicate that hydroclimates were substantially the same or warmer than those in the same regions today, and that depositional environments were fully within the present bathymetric range of *B. trigonus*. The origin and historical biogeography of *B. trigonus* remain in doubt, and their resolution will, in part, be dependent on a thorough evaluation of previously reported occurrences.

Balanus sp., cf. **B. calidus** Pilsbry, 1916
Figures 15, 16

Material.—One complete shell, CASG locality 61392.

Discussion.—A single shell, lacking opercular plates, is tentatively identified with *B. calidus* based on its coarsely ribbed, volcaniform shell and small orifice. Only a few extant specimens of *B. calidus* were obtained during the 1964 expedition, and all came from shallow, subtidal depths. Off the East Coast of the United States, *B. calidus* is found on the shelf at depths below significant wave action.

Balanus poecilus Darwin, 1854
Figures 17–19

Balanus poecilus Darwin, 1854:246, pl. 5, fig. 3a, b; Henry 1960:142, pl. 2, fig. a, c, d, pl. 5, fig. b–d.

Material.—Eight shells without opercular plates, CASG locality 61392.

Discussion.—The "west coast of South America, Mus. Cuming; attached to an *Avicula*" was cited by Darwin (1854) as the type and only locality in his original description of *B. poecilus*. The species went unreported until Henry (1960) obtained some individuals of *Pteria sterna* (Gould) from the vicinity of Guaymas in the Gulf of California. Because of the unusually broad distribution indicated by the recorded occurrences, and because of the ambiguity of the type locality, I requested the aid of J. P. Harding, British Museum (Natural History) in attempting to refine these data through identification of the "*Avicula*" to which the types are attached. Dr. Harding kindly located the type-lot and forwarded the following information provided by S. P. Dance (personal communication August 5, 1965):

> The shell to which the type specimens of *Balanus poecilus* Darwin are attached closely resembles a recently described species, *Pteria beilana* Olsson. The type locality for this species is Venado Beach, Canal Zone, Panama. *Pteria peruviana* Reeve *may* be an earlier name for this taxon but there is not enough material in the British Museum (Natural History) collections to decide this. Whichever name is used for it there can be little doubt that the shell to which the Darwinian barnacles are attached is a member of the Panamic-Pacific faunal province.

Dr. Harding also reported that the specimens bear the label "West coast of America," rather than South America, and as it is known that Hugh Cuming made extensive collections on the west coast of Central America, and especially in Panama during the period 1832–1856 (Keen 1958:2), it seems likely that the types of *B. poecilus* are from the same region.

Based on collections made during the 1964 Galápagos expedition, and previously unreported specimens in the collections of the Allan Hancock Foundation and the California Academy of Sciences, *Balanus poecilus* is found to range throughout the Panamic faunal province. The Allan Hancock Foundation collection includes specimens from off San Pedro Nolasco Island in the Gulf of California, off Jicarita Island and Bahia Honda, Panama, off Gorgona Island, Colombia, and off La Libertad, Ecuador, as well as from the Galápagos off Gardiner Island, near Española.

Genus **Concavus** Newman
Subgenus **Arossia** Newman

Concavus (Arossia) sp.,
cf. **C. (A.) panamensis eyerdami** (Henry, 1960)
Figures 22–24

MATERIAL.—Two shells without opercular plates, CASG locality 61390.

DISCUSSION.—The genus *Concavus* is not known to be represented in the extant Galápagan fauna. According to Newman (1982), modern representatives of this Tethyan Tertiary genus are restricted to the eastern Pacific, ranging from San Francisco, California to Valparaíso, Chile. Newman (1982) established two subgenera for extant species: *Menesiniella* for *C. aquila* (Pilsbry) and *C. regalis* (Pilsbry); and *Arossia* for *C. henryae* Newman, *C. panamensis panamensis* (Rogers), and *C. panamensis eyerdami* (Henry). The Galápagan fossils, with their plicate, but not regularly or strongly ribbed parietes, appear to be assignable to *Arossia* in the absence of the more definitive features of the opercular plates. Within *Arossia*, these fossil shells most closely approach those of *C. panamensis eyerdami* in having a high conic shell with the rostrum higher than wide, a straight carina, and no evidence of beaded growth lines. The preserved reddish-purple coloration of the shell and the closely spaced transverse septa appear to distinguish the fossils from *C. henryae*, the sole representative of *Concavus* in the Peruvian faunal province.

Subfamily MEGABALANINAE Newman
Genus **Megabalanus** Hoek

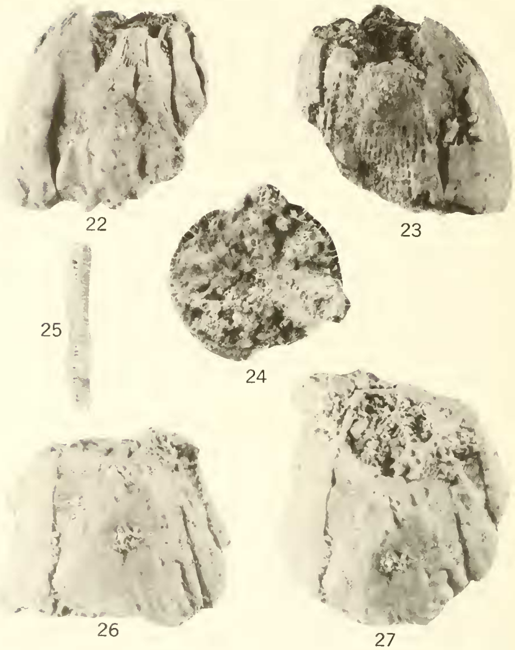
Megabalanus galapaganus Pilsbry, 1916
Figures 28–35

Balanus tintinnabulum galapaganus Pilsbry, 1916:70, pl. 12, fig. 1–1b.

MATERIAL.—Eight shells, 5 shell fragments, CASG locality 61281; 2 partial shells, CASG locality 61282; 24 shells, 26 compartmental plates, two bases, four scuta, and one tergum, CASG locality 61286; 2 shells, CASG locality 61392.

DISCUSSION.—After *Tetraclita milleporosa*, shells of *Megabalanus galapaganus* are the most abundant barnacle fossils obtained during the 1982 expedition. The specimens range from recently settled juveniles to mature individuals over 5 cm in height and 4 cm in greatest diameter. Many individuals retain the parietal color or color striping, and the parietal spines characteristic of extant populations. The opercular plates, although somewhat worn, are typical for *M. galapaganus*. The scutum is flat, bears a well-defined adductor ridge, and lacks a definite lateral depressor muscle pit. The tergum has a longer and narrower spur than the closely related species *M. clippertonensis* (Zullo) from Clipperton Island and *M. tanagrae* (Pilsbry) from the Hawaiian Islands (Zullo 1969).

Extant *M. galapaganus* is relatively abundant in low intertidal rocky areas subject to heavy



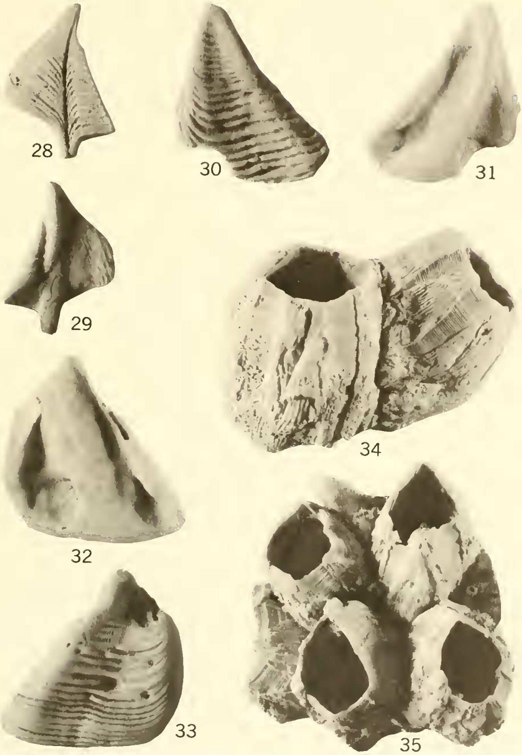
FIGURES 22–27. Fig. 22–25. *Concavus* sp., cf. *C.* (*Arossia*) *panamensis eyerdami* (Henry, 1960), CASG locality 61390; ×1.6. Fig. 22, 23. Lateral views of shell, hypotype CASG 61377. Fig. 24. Basal view of shell, hypotype CASG 61378. Fig. 25. Broken radial sutural edge showing tubes, hypotype CASG 61378. Fig. 26, 27. *Megabalanus* sp. indet., lateral views of shell, hypotype CASG 61379, CASG locality 61285; ×2.5.

wave shock. It is in this region that the species reaches its maximum size. At subtidal depths specimens are locally abundant on lobster carapaces, gastropod shells, and coral heads, but rarely attain more than 2 cm basal diameter and are usually less than 1 cm high. Pilsbry (1916) based this species on specimens from the intertidal of Española Island. Collections made during the 1964 expedition and augmented by collections from the Allan Hancock Foundation and the California Academy of Sciences extend the range of *M. galapaganus* not only through most of the Galápagos Archipelago but to Cocos Island (Costa Rica) to the north and Port Utria, Colombia on the South American mainland.

Megabalanus sp. indet.

Figures 26, 27

MATERIAL.—One shell without opercular plates, CASG locality 61285.



FIGURES 28–35. *Megabalanus galapaganus* (Pilsbry, 1916). Fig. 28, 29. Exterior and interior of tergum, hypotype CASG 61380, CASG locality 61286; ×1.3. Fig. 30, 31. Exterior and interior of scutum, hypotype CASG 61381, CASG locality 61286; ×1.3. Fig. 32, 33. Interior and exterior of scutum, hypotype CASG 61382, CASG locality 61286; ×1.3. Fig. 34. Lateral view of shells, hypotype lot CASG 61383, CASG locality 61286; ×1.0. Fig. 35. Top view of shell clump, hypotype CASG 61384, CASG locality 61282; ×1.0.

DISCUSSION.—The single barnacle specimen from CASG locality 61285 differs sufficiently from the typical growth form of *M. galapaganus* to question its identification. The shell is 15 mm high, 22 mm in carinorostral diameter, and is low conic, rather than cylindric to subglobose in

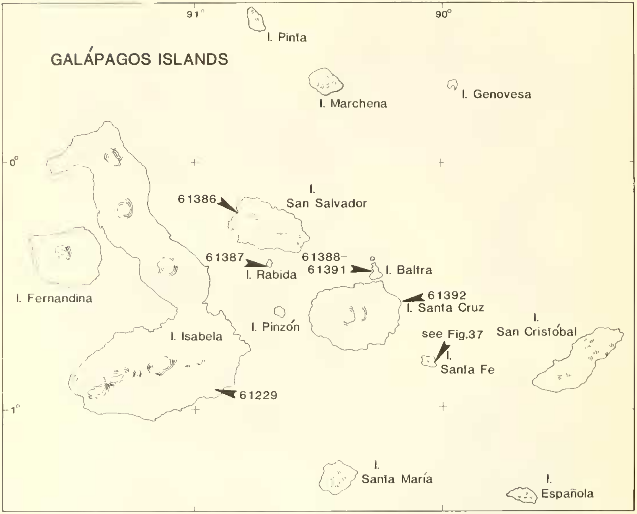


FIGURE 36. Generalized map of CASG Galápagos localities containing fossil barnacles (map provided by J. H. Lipps).

shape. The sub-diamond-shaped orifice is, resultingly, rather small, and the radii are correspondingly narrow. The parietes show no evidence of color or striping, and bear low, rounded, irregular ribs. In the absence of opercular plates, however, there is no way to determine its identity.

Locality Descriptions

All barnacle specimens are in the collection of the Department of Geology, California Academy of Sciences, San Francisco (CASG). Locations of collection sites are shown in Figures 36 and 37.

61229 Isla Isabella. White to tan, loose, silty sand containing abundant shells at site of airport at Villamil. Collected 3 February 1982. *Coronula diadema.*

61281 Isla Santa Fe. Beach deposit about 8 m above sea level on southeast shore north of Punta Miedo. Calcareous, sometimes stratified sand up to 2.5 m thick and intermixed with basalt boulders and cobbles. Collected 14 February 1982. *Chelonibia testudinaria, Tetraclita milleporosa, Megabalanus galapaganus.*

61282 Isla Santa Fe. Fossils from top of sedimentary sequence overlain by basalt. Red, tuffaceous, crossbedded sandstone with stratified fossils at top, about 8 m above sea level. Same horizon as CASG locality 61281, but 30 m farther seaward. Collected 14 February 1982. *Tetraclita milleporosa, Megabalanus galapaganus.*

61285 Isla Santa Fe. Terrace deposits of boulders, cobbles, pebbles, and sand containing molluscs and barnacles at top of cliff in small cove at landing site; 3.5–4 m above sea level. Locality is north of CASG locality 61282. Collected 15 February 1982. *Megabalanus* sp. indet.

61286 Isla Santa Fe. Terrace deposit about 100 m from shore near eastern end of south coast. Loose, white to tan, medium- to coarse-grained sand containing many barnacles. Collected 15 February 1982. *Tetraclita milleporosa, Tetraclita* sp. indet., *Megabalanus galapaganus.*

61386 Isla San Salvadór, James Bay. Shelly, basaltic sand in line of trees north of mining camp. Collected 8 February 1982. *Tetraclita milleporosa.*

61387 Isla Rabida. Storm-tossed shell and bone in small, cliff-

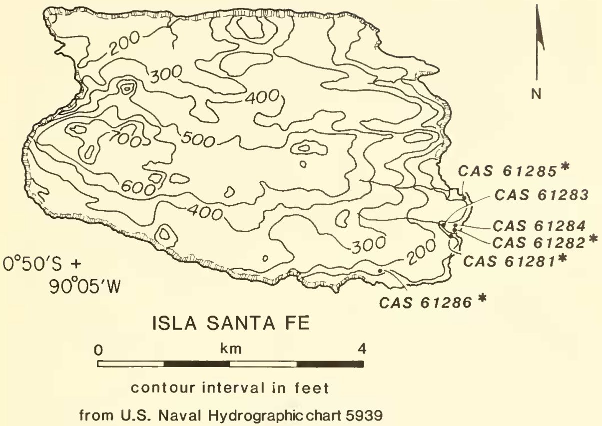


FIGURE 37. Collecting sites on Isla Santa Fe. CASG localities with asterisks yielded barnacles (map provided by J. H. Lipps).

backed cove on south side of island. Collected 9 February 1982. *Tetraclita milleporosa.*

61388 Isla Baltra. Bedded to crossbedded, reddish-brown, silty sandstone with abundant *Codakia* shells at basal contact (Unit 4). South shore of Caleta Aeolian, directly south of Punta Noboa. Collected 10 February 1982. *Balanus trigonus.*

61389 Isla Baltra. Crossbedded, white sandstone containing shell debris and abundant pectinids (Unit 1). Locality about 30 m east of CASG locality 61388 along a 100-m stretch of exposure. Collected 10 February 1982. *Balanus trigonus.*

61390 Isla Baltra. Basal 0.5–1.5-m-thick boulder and cobble bed containing abundant coralline algae and casts and molds of molluscs. Same area as CASG locality 61389. Collected 10 February 1982. *Balanus trigonus, Concavus* (*Arossia*) sp., cf. *C.* (*A.*) *panamensis eyerdami.*

61391 Isla Baltra. Bulldozed pit (?old anti-aircraft gun emplacement) about 170 m back of sea cliff. Collected 10 February 1982. *Tetraclita milleporosa.*

61392 Isla Santa Cruz, Cerro Colorado. Fossils from top of limestone shelf on north side of Cerro Colorado. Collected 17 February 1982. *Balanus trigonus, Balanus* sp., cf. *B. calidus, B. poecilus, Megabalanus galapaganus.*

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CALIFORNIA ACADEMY OF SCIENCES
Golden Gate Park
San Francisco, California 94118